Common and Aberrant Flowers of *Cassia fistula*

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While collecting herbarium specimens from golden shower trees (*Cassia fistula* L., a legume from India) at my home in Nuuanu Valley, Honolulu, I noticed that three of our four trees (A, C, D) bore the common form of flowers and that a fourth (B) bore aberrant forms. This discovery led to the examination of other trees of the same species. After studying from June to September, 1948, four or more flowers of each of 26 trees of *C. fistula* in seven different localities in Honolulu, I found that trees A, C, and D definitely bore the common form of flowers, which were nearly uniform. Only tree B bore flowers deviating distinctly from those borne by the other trees. Examination of all these flowers and also of literature dealing with *C. fistula* led to two conclusions: (1) The stamens of the common form of *C. fistula* needed redescription; and (2) the petals, sepals, and stamens of the aberrant form of *C. fistula* differed in several ways from those of the common form.

COMMON FLOWERS

The common form of the flower of *C. fistula* has 5 petals, 5 sepals, and 10 stamens, and it has been described many times. Wight (1840, pl. 269) has a figure which more or less epitomizes these descriptions and from which is here reproduced a detail (Fig. 1), showing flowers for comparison with my drawing (Fig. 2). In Wight's figure, the three shortest stamens appear to be alike. The petals and sepals of published descriptions seemingly were like those of flowers on 25 of the trees examined by me. The stamens, however, were different. As seen in a diagram of the receptacle (Fig. 3), the 10 stamens are actually arranged in two series, the five inner ones being opposite the five petals, the five outer ones being opposite the five sepals. The five inner stamens, Nos. 2, 4, 6, 8, 10 (Fig. 2, *A*, *B;* Fig. 4, *A–D*), have rather short filaments and versatile, two-celled, slightly compressed, curving-obovoid anthers, each cell opening by a basal pore. No. 2, the uppermost stamen,

Fig. 1. Flowers of *Cassia fistula*, reproduced from Wight's plate; letters added to petals to agree with Figure 2.

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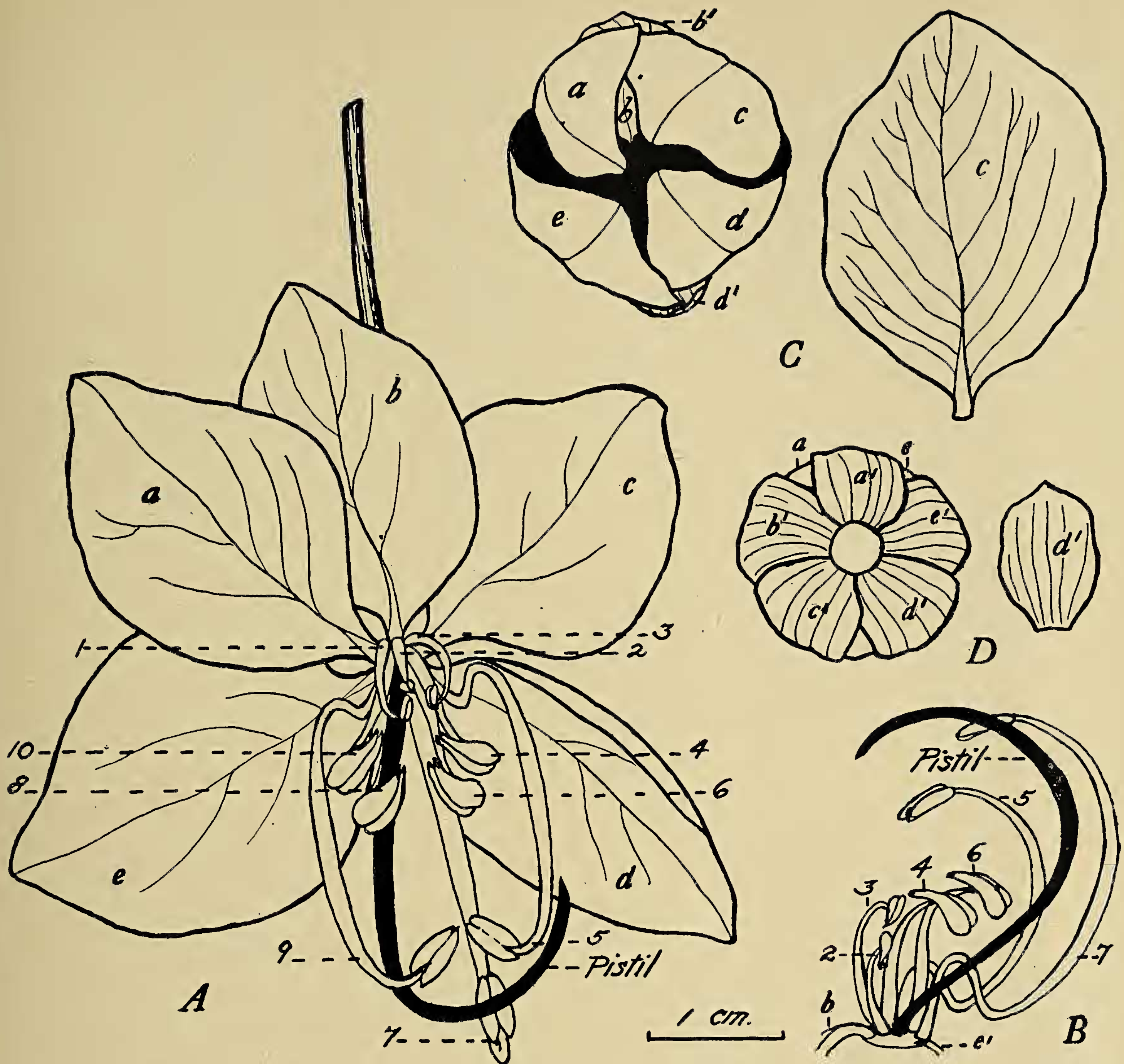

Fig. 2. Flower of *Cassia fistula* from tree C. *A*, Front view: *a–e*, petals; 1, 3, 5, 7, 9, outer, fertile stamens; 2, 4, 6, 8, 10, inner, sterile, starch-bearing stamens. *B*, Arrangement of stamens on right side of flower. *C*, Bud, front view: *a–e*, petals; *c*, single petal. *D*, Bud, back view: *a'–e'*, sepals; *d'*, single sepal.

has the shortest filament and (with Nos. 1 and 3) the smallest anther, and it faces Nos. 4, 6, 8, and 10. Nos. 4 and 10 are paired and are borne on longer filaments than No. 2. Nos. 6 and 8 are paired and are borne on slightly longer filaments than Nos. 4 and 10. All five of these stamens yield pollen.

The five outer stamens, Nos. 1, 3, 5, 7, 9 (Fig. 2, *A, B;* Fig. 4, *E–H*), have two-celled, compressed, ovoid anthers, each cell opening by an interrupted longitudinal cleft. Two of these stamens, the upper ones (Nos. 1 and 3), are paired and have short, twisted filaments, little longer than the filament of No. 2, and small, versatile anthers about the size of the anther of No. 2. The other three, lower stamens (Nos. 5, 7, 9), are similar to one another. They have the longest filaments, which curve outward after making a short backward bend at the base, and they bear at their distant tips anthers tending to be slightly smaller than those of Nos. 4, 6, 8, and 10; and though they are not basifixed they are not versatile, but continue in a line with their filaments. All five of these stamens yield pollen.

My description of the 10 stamens does not agree entirely with any I have found in botanical literature. Taubert (1891: 158) states in a summary of subgenera of *Cassia* that sub-

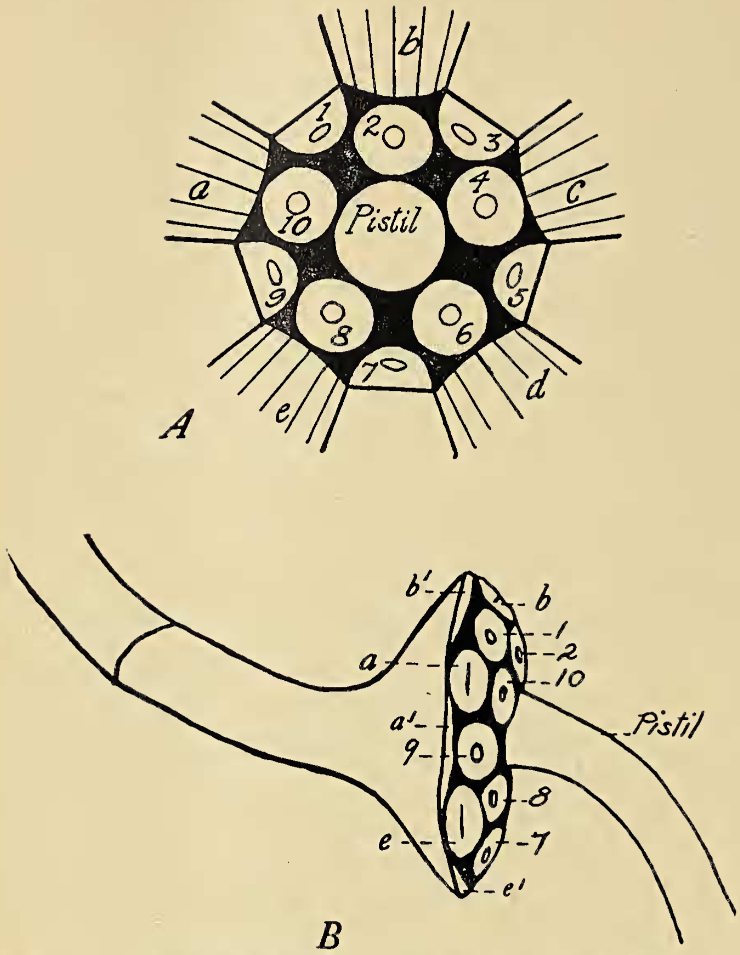

FIG. 3. Receptacle of common form of flower of *Cassia fistula*. *A*, Diagram, front view, showing points of attachment of stamens (1–10) in relation to petals (*a–e*) and pistil. *B*, Side view, showing also points of attachment of sepals *a′*, *b′*, *e′*.

genus *Fistula*, to which *C. fistula* belongs, has the three lower stamens (my Nos. 5, 7, 9) with long, bent filaments, and with anthers opening by longitudinal clefts; the seven upper stamens with short filaments and with anthers opening by basal pores; the anthers of the one to three uppermost stamens (my Nos. 1, 2, 3) sometimes abortive. This description of the stamens of *C. fistula* or the subgenus *Fistula* is the description commonly found, the majority of opinions being that the three smallest stamens (my Nos. 1, 2, 3) were alike and without pollen (and, according to some authorities, indehiscent); that the arrangement was seven (or four) anthers with basal pores and the three on long filaments with longitudinal clefts.

Examples of descriptions of the stamens of *C. fistula* follow:—Bentham and Hooker (1865: 572): "Stamina perfecta 10, filamentis 3 inferioribus elongatis, antheris saepius oblongis breviter 2-rimosis, 7 superioribus abbreviatis antheris minute 2-porosis." Trimen (1894: 103, 104): "3 lowest stam. with very long doubly curved exserted fil. and oblong anth. dehiscing longitudinally, 4 lat. ones with short straight fil. and versatile anth. opening by pores at the base, 3 uppermost ones much smaller, erect, with indehiscent abortive anth." Brandis (1907: 253): "The three lower stamens have long curved filaments and anthers, which open by longitudinal slits, four stamens have short filaments and anthers opening by basal pores; the rest have minute anthers without pollen." Rock (1920: 75): "Three stamens with long filaments, 7 stamens with short filaments, anthers of three basifixed opening in longitudinal slits, anthers of seven dorsifixed opening in basilar pores."

As seen by my diagrams and descriptions, the arrangement is of five stamens of each of two kinds in two series, one series opposite the petals, the other opposite the sepals. I have examined the pollen of the "abortive" stamens (Nos. 1, 2, 3) and found apparently normal grains, some slightly smaller than some of those of No. 8, for example, which, however, were turgid with starch. Some of the grains of Nos. 1, 2, 3, also, were slightly smaller than those of Nos. 5, 7, 9, even after the starch contents of Nos. 5, 7, 9 had evidently been converted in mature flowers from starch by diastase (Tischler, 1910: 241). Grains of Nos. 1, 2, 3, from flowers at different stages of development, were tested for starch and dextrin (with iodine dissolved in potassium iodide) and were found to contain varying amounts of both. Thus it seems probable that the small stamens do function—Nos. 1 and 3 like Nos. 5, 7, 9, No. 2 like Nos. 4, 6, 8, 10.

Tischler (1910: 220) agreed with Knuth (1904: 375–377) in Knuth's description of the stamens of *C. fistula*, which is translated as follows (Knuth had studied the flower ecology of *C. fistula* in Buitenzorg):

Cassia fistula has three abortive stamens; these have anthers to 2 mm. long, which are bent inward and are borne on filaments to 10 mm. long. Because of their nature and position they serve chiefly as footholds for the wood bee. Next to them are the four starch-bearing, sterile stamens with filaments 10 mm. long and anthers 5 mm. long. Three fertile stamens arise from the flower's base, the filament basally being directed upward, then after 5 mm. suddenly turning backward, and finally bending in a large curve out of the flower, so that the 5×2 mm. anthers are to 25 mm. from the flower base.

Tischler states that he has nothing to add to this description and that like Knuth he saw the pollinating wood bee "milk" the starch-bearing anthers (my Nos. 4, 6, 8, 10) for food and get pollinated by the fertile anthers (my Nos. 5, 7, 9), the pollen of which it then carried to stigmas of other flowers.

The position of the style may be between stamens Nos. 5 and 7 or between Nos. 7 and 9.

ABERRANT FLOWERS

The cause of the aberrations in tree B is not known. The four trees in our garden, A, B, C, D, are about 12 years old. The 22 other trees examined are probably older. The general aspect of tree B is like that of the common form of *C. fistula*. But the leaves are slightly shorter and the leaflets smaller than those of A, C, D; none, however, was malformed. According to Ridgway's Color Chart, the "wax yellow" flowers of tree B are a duller yellow than the "lemon chrome" flowers of tree A, for example; this comparison, on being analyzed, shows that the flowers of both B and A have the same hue, orange-yellow-yellow (25 per cent orange, 75 per cent yellow), but that "wax yellow" is grayer, a stage nearer neutral. Besides other differences of the flowers, some racemes though at first as large soon become small and rounded, with flowers clustered at the tip only, instead of remaining long and more or less obconical, as in the common form; other racemes are small and rounded from the beginning. The seeds look like those of tree A, for example; but the pods are far fewer, some are shorter, and others have constrictions.

All these slight differences might well be within the range of the species. Hybridism does not explain the differences, since the regular shaped sepals, petals, and stamens found among the irregular shaped ones of tree B were much like those of the common form of flower of trees A, C, and D.

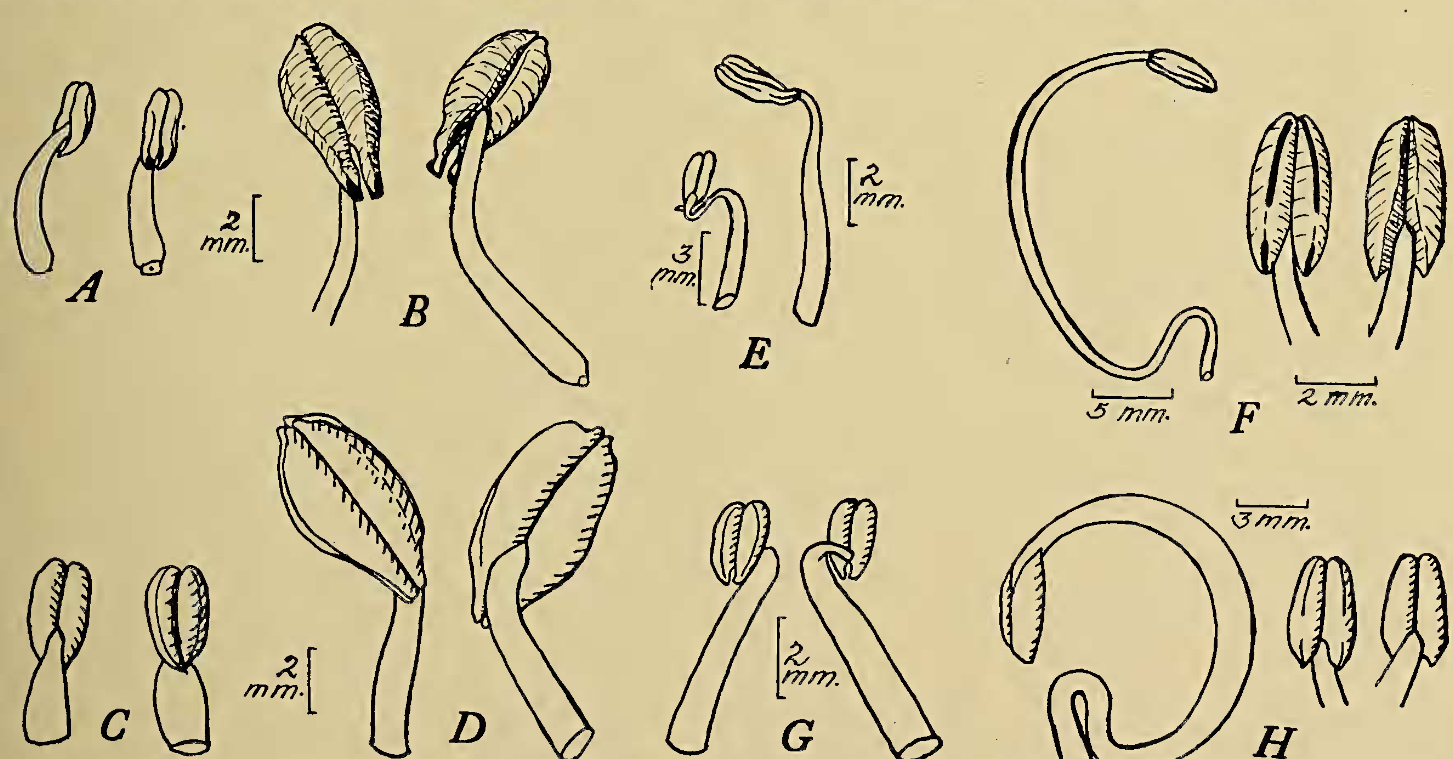

Fig. 4. Stamens of common form of flower of *Cassia fistula*, front and back views. Upper row: mature stamens from open flower, anther cells open. Lower row: stamens from bud, anther cells not open. *A* and *C*, No. 2; *B* and *D*, No. 8; *E* and *G*, No. 1 (*E* shows No. 1 from two different flowers); *F* and *H*, No. 9.

FIG. 5. Flowers of *Cassia fistula* from tree B. *A*, A form with four petals (*d* missing) and eight stamens (Nos. 6, 7 missing). *B*, A slightly irregular form with the common number of stamens, petals, and sepals. *C*, A form with three of five petals much modified; eight stamens (Nos. 1, 8 missing), with anthers borne on two petals (see Fig. 6, *C*). *D*, A form with three of five petals contorted, one bearing an anther cell; nine stamens, No. 2 missing. *E*, A form with three petals (*c* and *d* missing); five sepals; seven stamens (Nos. 3, 4, 6 missing). *F*, Back view of *E*.

The possibility that 2,4-D was the cause has been suggested. For 2 or 3 years before this study was made, trees A and B were exposed to 2,4-D, which was applied in solution from a watering pot on the ground near their trunks in order to rid that part of the lawn of pennywort and other weeds. This treatment did not seem to affect tree A. In July, 1949, a year later, and without another application of 2,4-D, tree B again bore aberrant flower forms. The effect of this hormone-like substance on herbs is temporary and comparatively short (Zimmerman, 1943); but the effect appears later and lasts longer on woody plants. Applications of 2,4-D to weeds along a fence of living hau (*Hibiscus tiliaceus* L.), at Kailua, Oahu, caused malformed leaves on the hau more than 6 months later;[2] flowers, being absent, were not studied. According to Zimmerman (1943), modified organs may well be caused by an environment (or chemicals) which permits different potentialities of the protoplasm to develop, inasmuch as "the so-called 'normal' characters of a plant are but a partial expression of the range of possibilities of which the protoplasm is capable."

Although I had not examined the flowers of tree B in detail until June, 1948, for years before then I had noticed the general appearance of the tree with its small, rounded racemes, and I believe it always has been different. In fact, it may be a sport. If so, this would also explain the comparatively small number of pods, which is characteristic of a sport and is not usually caused by 2,4-D (van Overbeek, 1946). Nonetheless it is possible that fasciation found on tree B in July, 1949, might have been caused by the application of 2,4-D the year before. The tree bore many more flowers in 1949 than in 1948, and among them were found four racemes with conspicuously flattened peduncles and rachises. No fasciation was noticed in 1948.

The striking difference in tree B is in the strange flowers. These vary in the same raceme, and they follow several patterns. One common form of flower on tree B had four petals, four sepals, eight stamens (Fig. 5, *A*). Another form had five petals, three of which were more or less irregular, four or five sepals, and eight to 10 stamens (Fig. 5, *B, C, D*). A third form had three petals, four or five sepals, and seven or eight stamens (Fig. 5, *E, F*).

The pistils were not noticed to differ from those of the common form.

The sepals were not all equal in size and some seemed to function as petals, one being large, rounded, and yellow (instead of green) where a petal was missing (Fig. 5, *E, F*). One or both of the innermost sepals (Fig. 2, *D, b′, e′*) seemed often to be petal-like. Although flowers on some of the 25 other trees examined were often found to have one or both of the inner sepals more or less petal-like, none reached the size of those on tree B.

The petals varied greatly in size and shape, from round to narrow and more or less curved. Some petals combined with filaments or substituted for them and bore anthers.

The stamens were very variable, both as to filaments and anthers. In extreme examples two anthers might combine, those studied combining an odd and even type anther, such as Nos. 3 and 4, with No. 3 at the tip (Fig. 6, *G*). The presence of an anther with either one or two cells on the edge of a petal was common. The anther was always found to be like the anther of stamens Nos. 1, 3, 5, 7, or 9 (Fig. 4, *E–H*), that is, the outer series of stamens opposite the sepals; and its pollen grains contained starch. Nos. 1 and 3 seemed more commonly malformed than 5, 7, or 9. The calloused edge of the petal from its base to the anther suggested a reduced filament. A calloused edge might end bluntly with a vestigial anther or none. A filament might be edged or tipped with yellow petal material. Some of these aberrations are illustrated (Fig. 6, *A–G*). The stamens and petals and the petals and sepals were partly interfunctional. But the stamens and sepals were not. This closer relationship between petals and sta-

[2]Personal communication from A. J. Mangelsdorf, 1949.

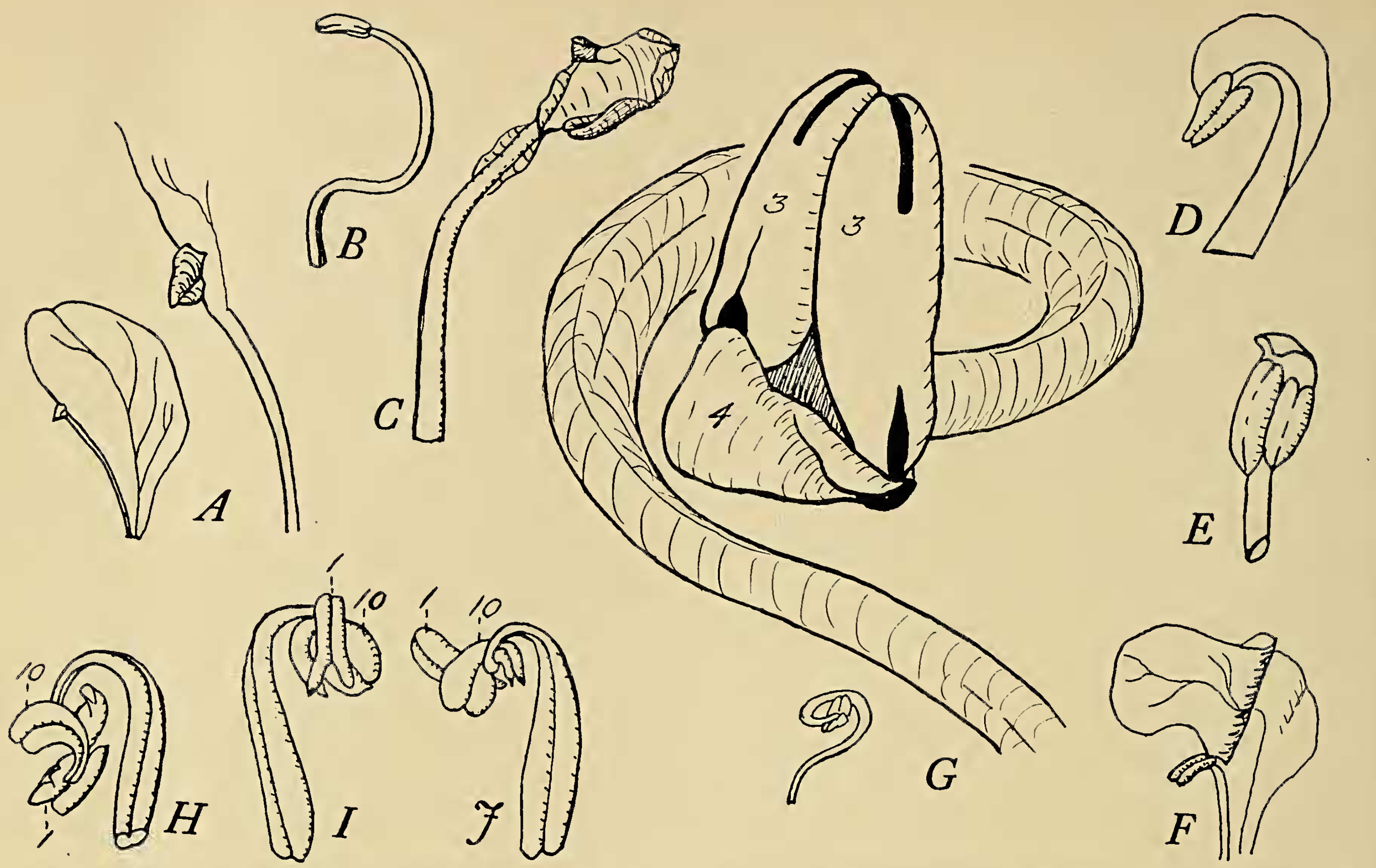

FIG. 6. Peculiar stamens and combinations of reduced stamens and petals in flowers of *Cassia fistula*: tree B (*A–G*), tree H (*H–J*). *A*, Reduced anther in five-petaled flower with eight stamens and four sepals. *B*, Stamen No. 1 imitating missing No. 9 but smaller. *C*, Stamen No. 1 on petal *a* (see Fig. 5, *C*). *D*, Stamen No. 3 on petal *c* (Nos. 7, 8, 9, and petal *b* missing). *E*, Stamen No. 7 on petal *e* (Nos. 1 and 9 missing, one of five petals, *e*, reduced). *F*, Stamen No. 1 on petal *b* (Nos. 9, 10, and petal *e* missing). *G*, Double stamen, Nos. 3 and 4 (Nos. 7, 8, and petal *d* missing). *H*, *I*, *J*, Three views of a double stamen, Nos. 1 and 10.

mens is confirmed by observations of plant anatomists, as by Eames (1931: 170), who, in figures of flowers, shows that vascular bundles of sepals, petals, and stamens may be united within the flower but that the bundles of the sepals may branch off much farther down than do those of the petals and stamens. Other instances of stamens being borne on petals or functioning as petals are sometimes found, as in double roses, double hibiscus, peonies, and water lilies. Many flowers having both calyx and corolla, as the mints and verbenas, bear stamens on the corolla tubes. In representatives of the ginger, canna, and maranta families, most of the stamens are sterile, conspicuous, and petal-like.

Among the 26 trees of *C. fistula* examined, two other oddities were found. On two trees, H and I, both near Bishop Museum, two aberrant forms of flowers were found. From tree I, five flowers were taken, four of which were of the common five-parted form. The other had the same arrangement, but six petals, six sepals, and 12 stamens (one extra of each of No. 5 and 6 forms). From tree H, nine flowers were taken. One flower was five-parted but aberrant in having stamens Nos. 4, 10, 6, and 8 not paired but of different lengths, No. 4 being the shortest, No. 10 a little longer, No. 6 longer, and No. 8 longest. Seven flowers were five-parted except that they had only nine stamens, the missing stamen being No. 4 or No. 10. With No. 4 missing, the base of petal *c* came to a point between stamens Nos. 3 and 5, which therefore stood close together. The ninth flower was five-parted throughout, but stamens Nos. 10 and 1 were joined, having a double filament and the anther of No. 1 standing just above the anther of No. 10 (Fig. 6, *H–J*). Some other flowers of tree H were examined and found to be the common five-parted form.

CONCLUSIONS

Conclusions concerning the common form of flower of *C. fistula:* The 10 stamens are arranged in two series. The five inner stamens are opposite the five petals. They have similar filaments and similar basiventral anthers, but one stamen is much smaller than the others. The five outer stamens are opposite the five sepals. They have similar anthers, which open by clefts; but two have smaller anthers and shorter filaments than the other three. The three so-called "abortive" stamens contain and discharge pollen as do the seven larger stamens.

Conclusions concerning the aberrant forms of flowers of *C. fistula* on tree B are that three forms which are irregularly three-, four-, or five-parted seem to dominate. Stamens and petals are more or less interfunctional, as also are sepals and petals, but not stamens and sepals. Inasmuch as all flowers examined on tree B deviated from the common form of the species, this tree may be a sport. It is possible that 2,4–D caused the fasciation in peduncles and rachises found in some inflorescences, but it is not likely that it caused the odd flower forms. It seems improbable that 2,4–D caused reduction in the size of the leaves, which were not malformed. Among the other trees examined, irregular flower forms may develop; but they are rare and not the rule.

REFERENCES

BENTHAM, G., and J. D. HOOKER. 1865. *Genera plantarum.* Vol. 1. xv+1040 pp. Reeve & Co., London.

BRANDIS, DIETRICH. 1907. *Indian trees.* xxxii +767 pp. Archibald Constable & Co., London.

EAMES, A. J. 1931. The vascular anatomy of the flower with refutation of the theory of carpel polymorphism. *Amer. Jour. Bot.* 18: 147–188.

KNUTH, P. 1904. *Handbuch der Blütenbiologie.* Band III. Leipzig.

ROCK, J. F. 1920. *The leguminous plants of Hawaii.* x+234 pp. Experiment Station, Hawaiian Sugar Planters' Association, Honolulu.

TAUBERT, PAUL. 1891. Leguminosae. In: Engler and Prantl, *Die natürlichen Pflanzenfamilien* III, 3. Wilhelm Engelmann, Leipzig.

TISCHLER, G. 1910. Untersuchungen über den Stärkegehalt des Pollens tropischer Gewächse. *Jahrb. f. wiss. Bot.* 47: 220–242.

TRIMEN, HENRY. 1894. *A hand-book of the flora of Ceylon.* Part 2. 392 pp. Dulau & Co., London.

VAN OVERBEEK, J. 1946. Control of flower formation and fruit size in the pineapple. *Bot. Gaz.* 108: 64-73.

WIGHT, ROBERT. 1840. *Icones plantarum indiae orientalis.* Vol. 1. Madras.

ZIMMERMAN, P. W. 1943. The formative influences and comparative effectiveness of various plant hormone-like compounds. *Torreya* 43: 98–115.